Methodology of Regional Climate Studies for West Texas and its Importance

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Overview of Presentation

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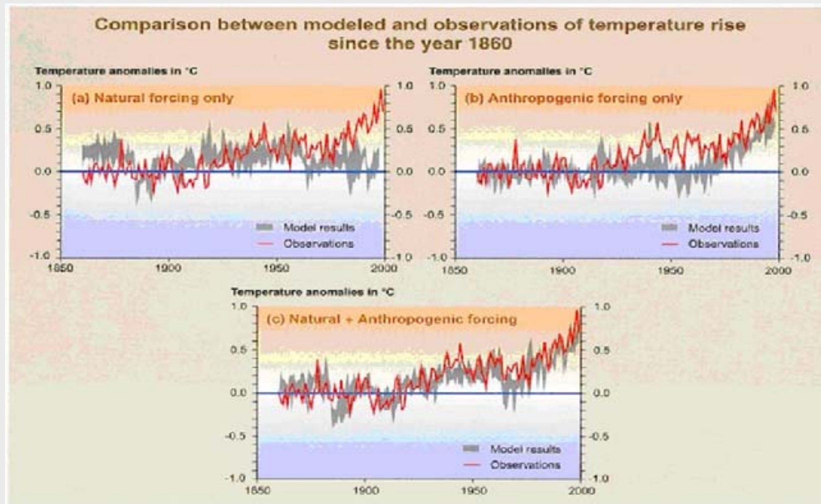
Introduction

Global average temperature sharply increased over past 100 years.

Along with natural variation, green house gases (GHGs) cause changes in long-term climate.



Climate Change Impact Modeling

Impact of climate change on processes and resources.

Changes in climate variables result in changes in hydrologic cycle.

Regional planners – mitigation/adaptation measures.

What are GCMs?

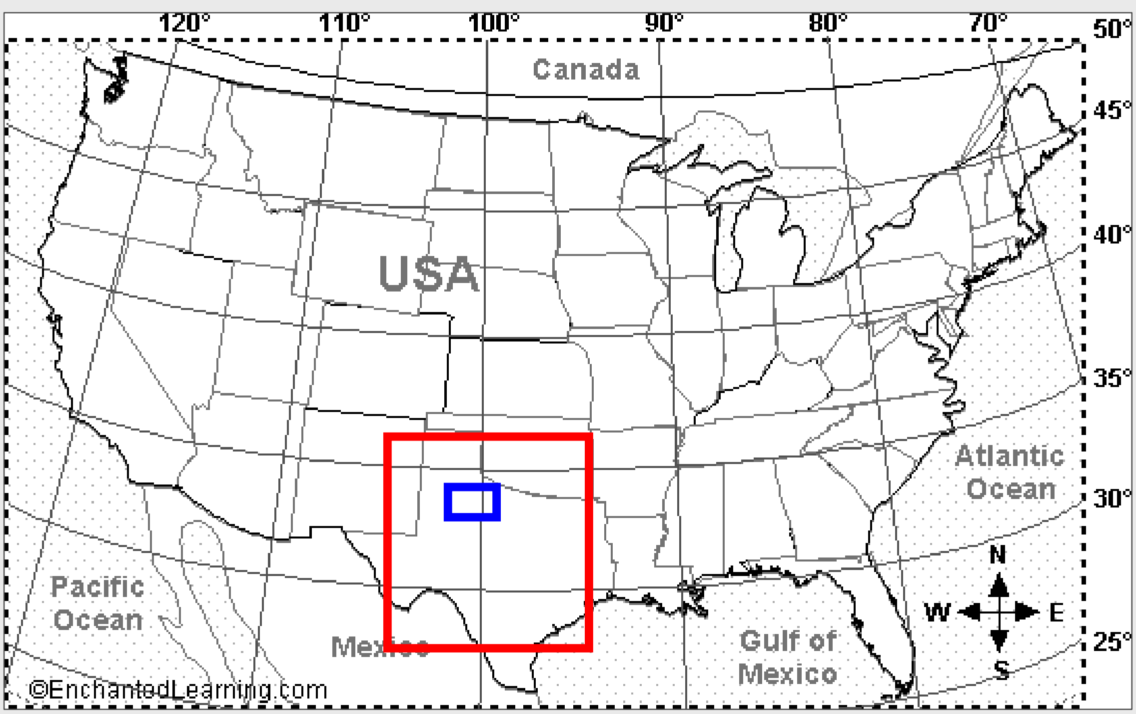
General circulation models.

Global coverage.

Long run lengths and computational times.

3^o - 7^o grid resolution.

Why GCMs to RCMs?



What are RCMs?

Models used to analyze impact of climate change.

Driven by observations, reanalysis data, and/or GCM output.

Grid size of RCM: approx. 1.0^{o} lat/lon.

Short run-lengths and less computing time.

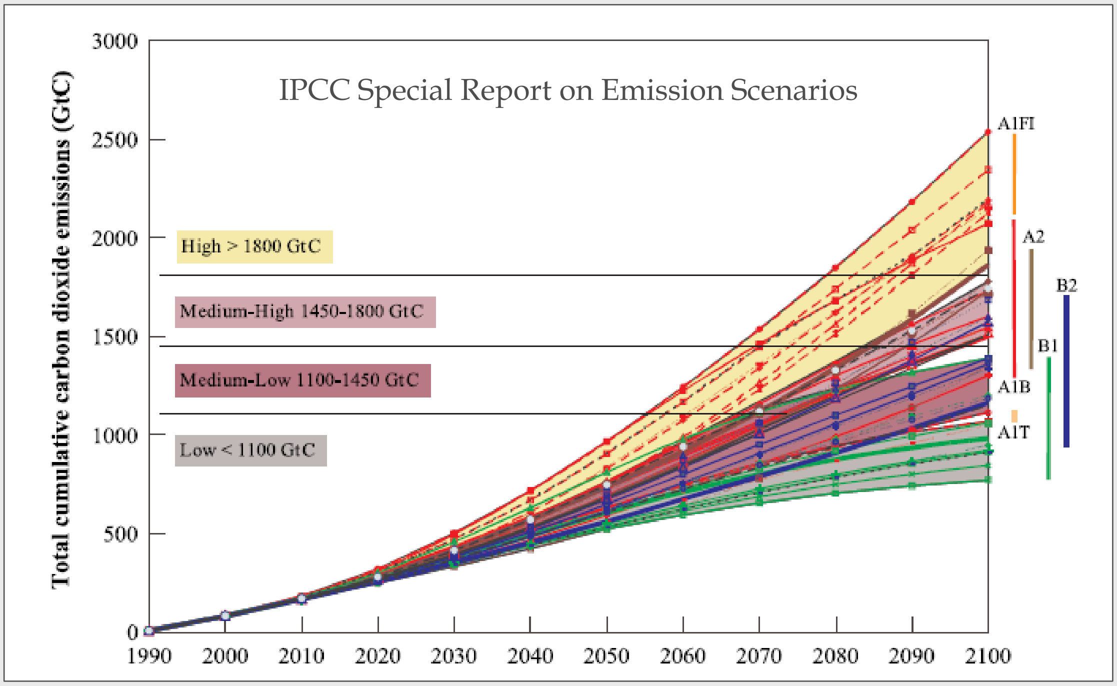
Scenarios representing climate change

Until 10-15 years ago, climate modelers used two scenarios, $1XCO_2$ and $2XCO_2$.

In 1992, IPCC developed IS92 a-f scenarios for business as usual (BAU) case.

In 2001, IPCC released special report on emission scenarios (SRES) with four scenarios.

Scenarios representing climate change



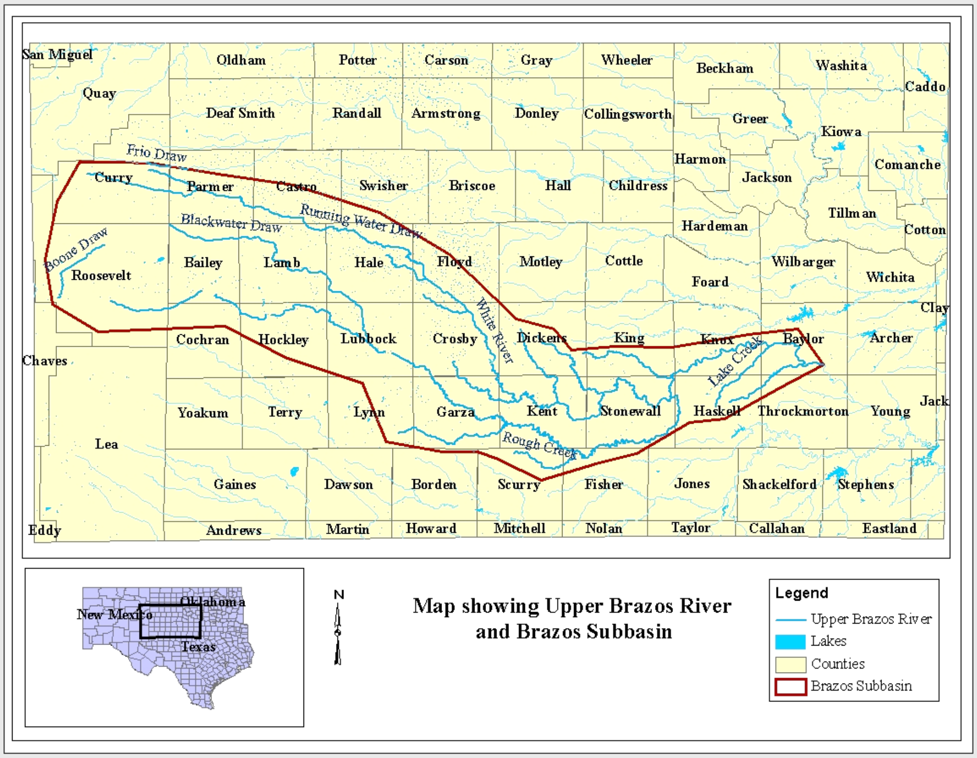
Objectives of the study

Methodology of Regional climate modeling for West Texas.

- Validate model for historic period.
- Select appropriate GCM to drive a RCM run.
- Conduct RCM run for future period.

Analysis of climate variables impacting hydrologic cycle for Upper Brazos.

Study area – Upper Brazos Basin



Why Upper Brazos River?

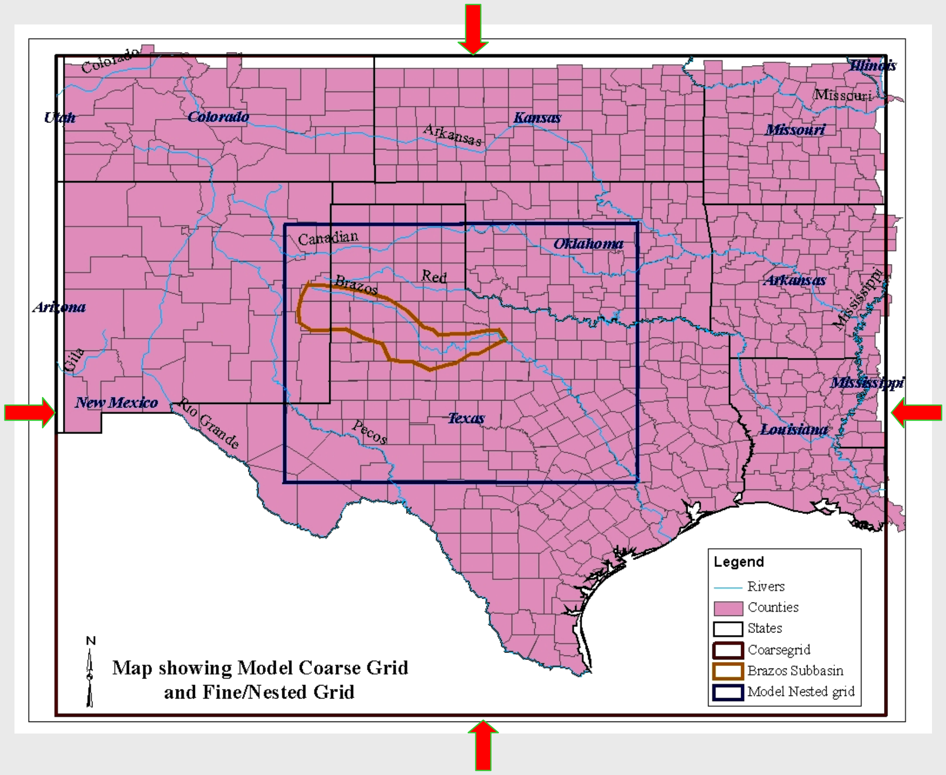
System representative of west Texas hydrology.

One of the sources of water supply in arid/semi-arid Texas.

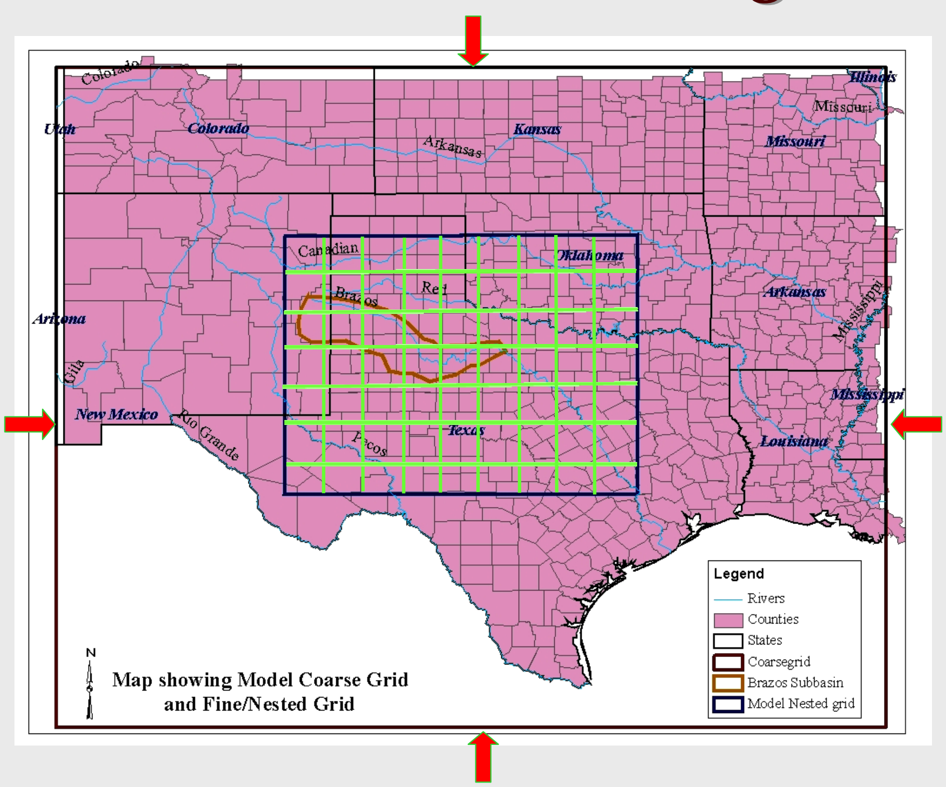
Unregulated system with fewer dams.

Few research projects focused on this region.

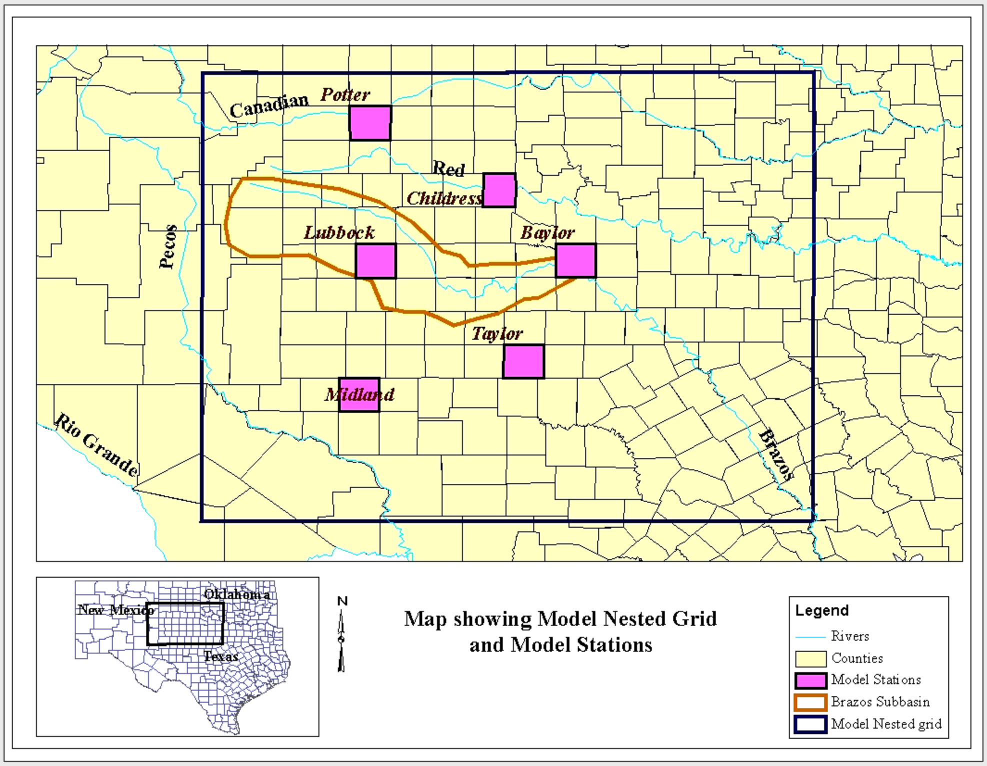
Location of coarse and fine grids



Location of coarse and fine grids



Locations of Model Stations



Methodology

Stage 1 → Phase I → Selection of RCM; Sensitivity studies; Historic run; Validation of RCM

Stage 2 → GCM selection → Method I; Method II

Stage 3 → Phase II → Future run

Methodology

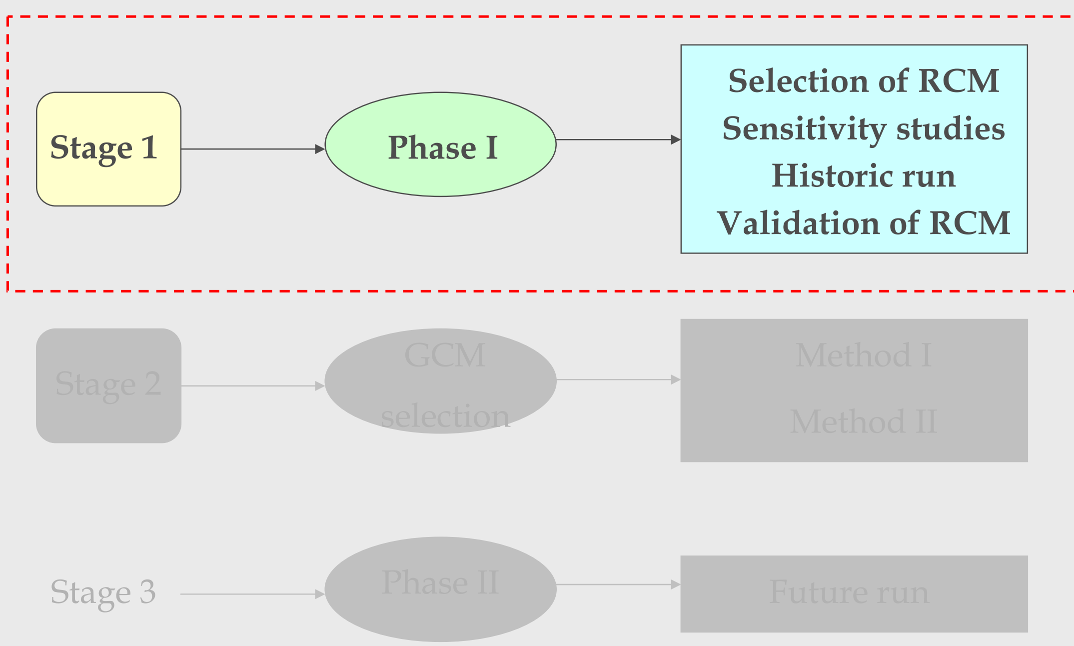
Run lengths

- Observations (1970-1990) – NCDC meteorological data and TWDB data
- Historic run (1970-1990) – using ERA40 reanalysis data
- Future run (2035-2055) – using CCSM GCM data

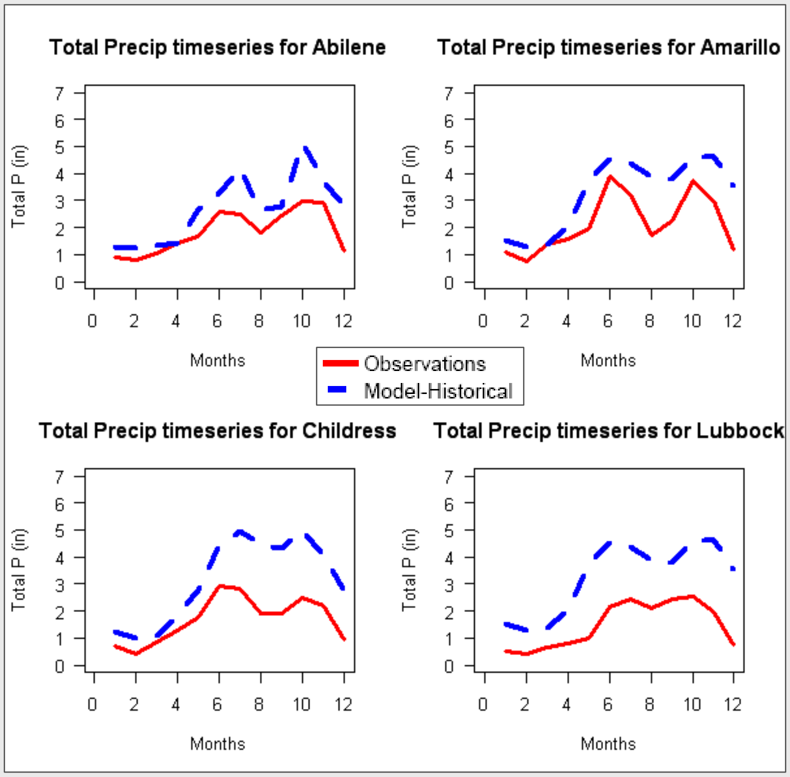
Climate variables

- Precipitation, Temperature, Evaporation, Surface Winds

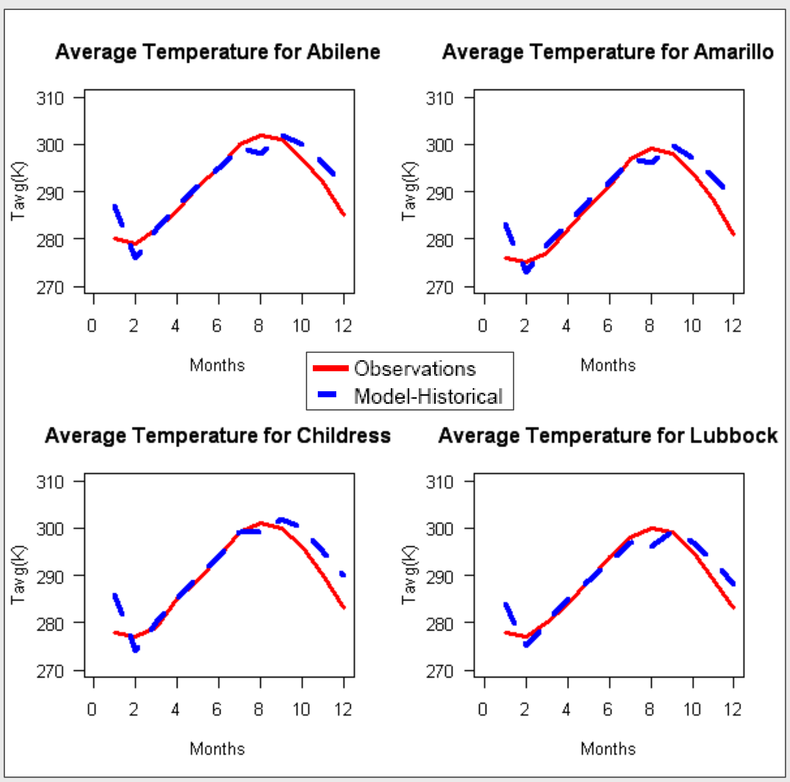
Results and Conclusions



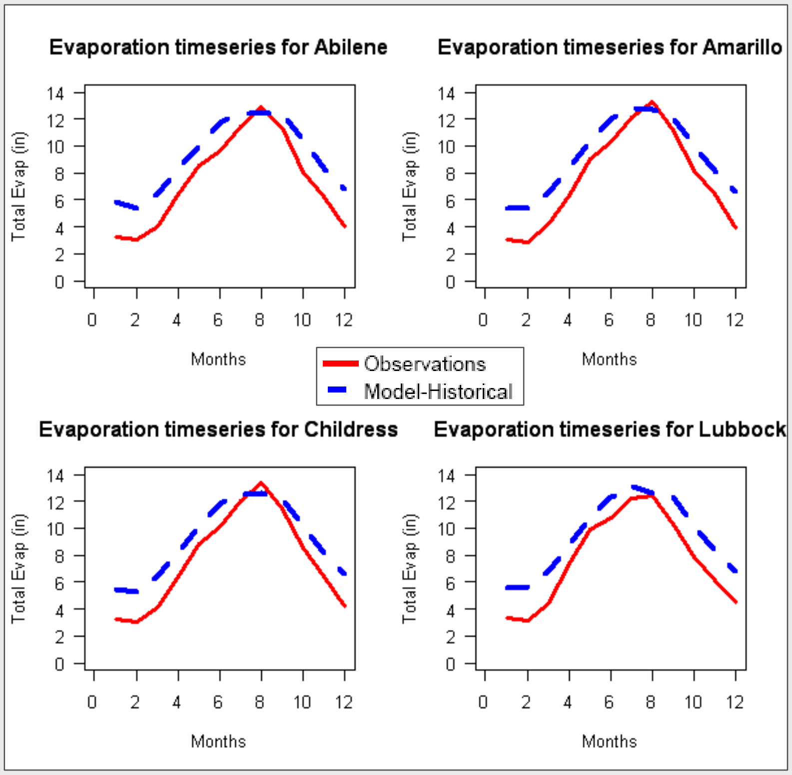
Historic run



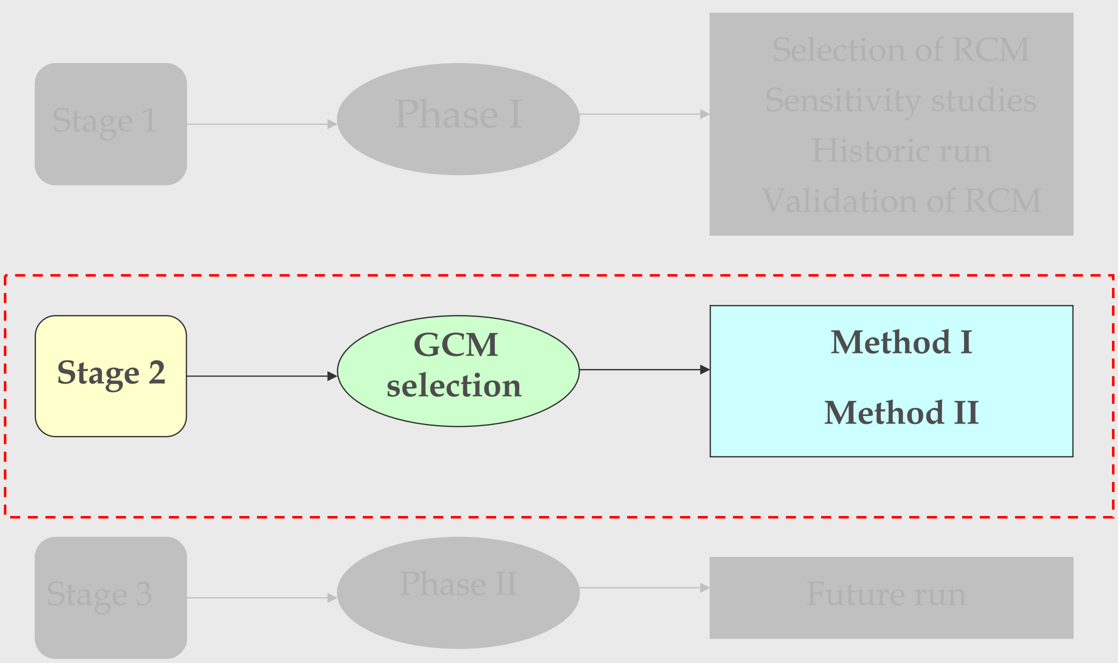
Historic run



Historic run



Results and conclusions



GCM comparison analysis

23 GCMs selected (ESG) initially.

Comparison analysis conducted using

- Method I: Comparison of jet stream movement by different GCMs with real-time representations of jet streams.
- Method II: Inter-comparison of magnitude of climate variables generated by different GCMs.

GCM comparison analysis - Method I

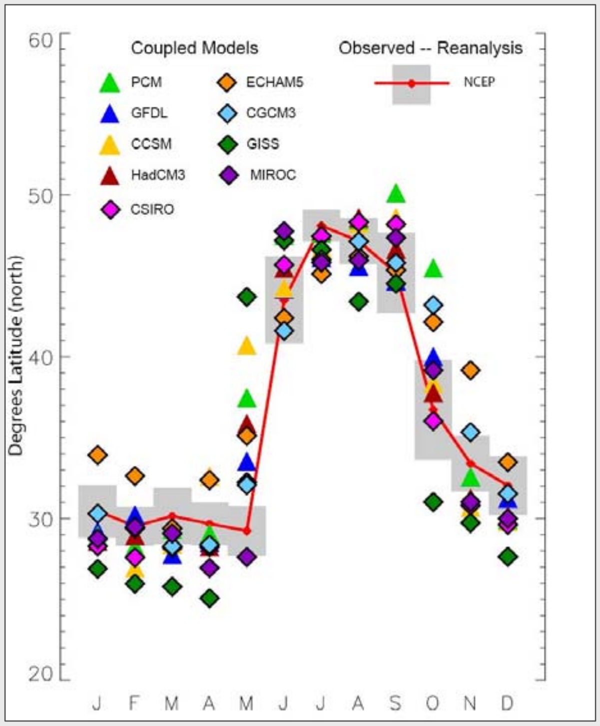
Methodology developed by Bradbury *et.al,* 2001.

Jet Latitude Index (JLI)

- monthly mean location of jet stream by means of 200 mb zonal winds speeds.

Comparison of JLI calculated for nine GCMs with that obtained using NCEP reanalysis data.

GCM comparison analysis - Method I



CCSM, GFDL, and HaDCM3 were selected.

GCM comparison analysis – Method II

Projected change is difference between future and historic averages.

Socio-economic uncertainty

– difference between mid-high (A2) and lower (B1) emission scenarios.

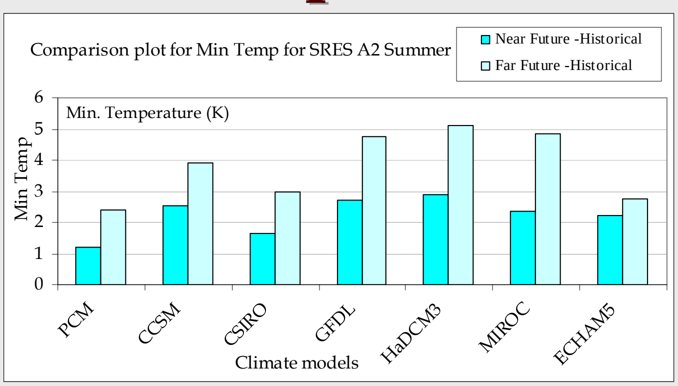
Climatic uncertainty

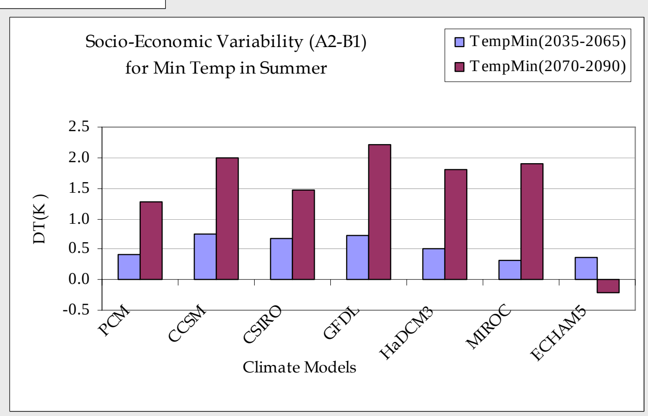
– different seasonal influences for given emission scenarios (A2, B1).

GCM comparison analysis – Method II

Summary of Method II of GCM comparison analysis	
Climate models	PCM, CCSM, CSIRO, GFDL, HaDCM3, MIROC, ECHAM5
Time periods	Historical (1960-1990), Near future (2035-2065), Far future (2070-2090)
Scenarios	SRES A2, SRES B1
Climate variables	Precipitation, Radiation, Relative Humidity, max. & min. Daily Temperature
Seasons	Winter, Summer

GCM comparison analysis – Method II



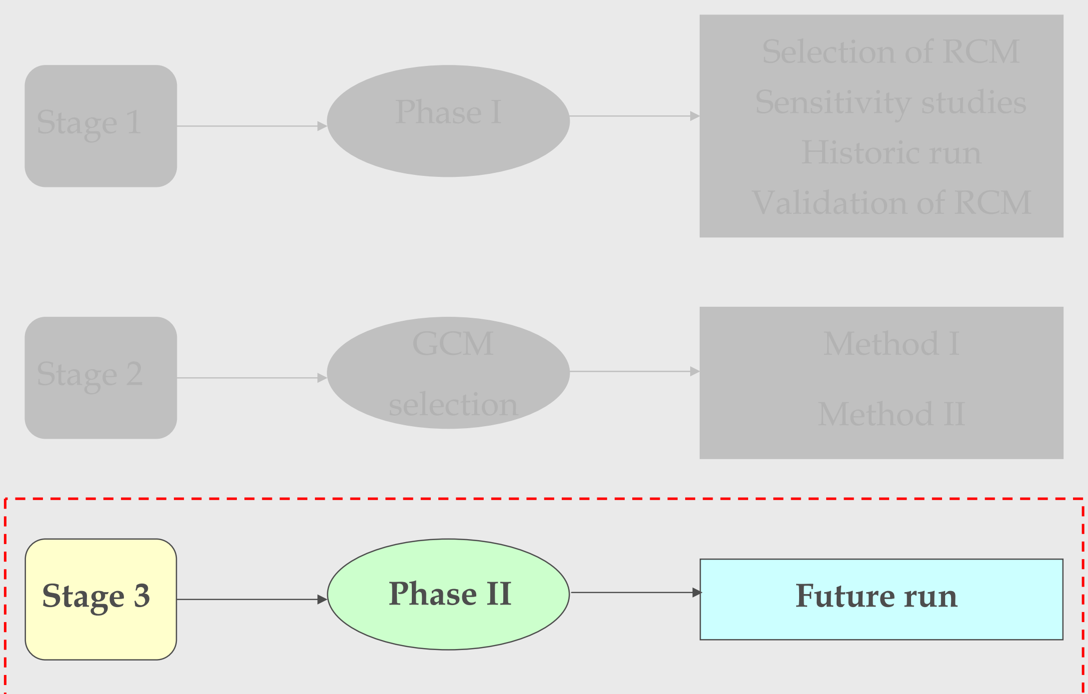


GCM comparison analysis – Method II

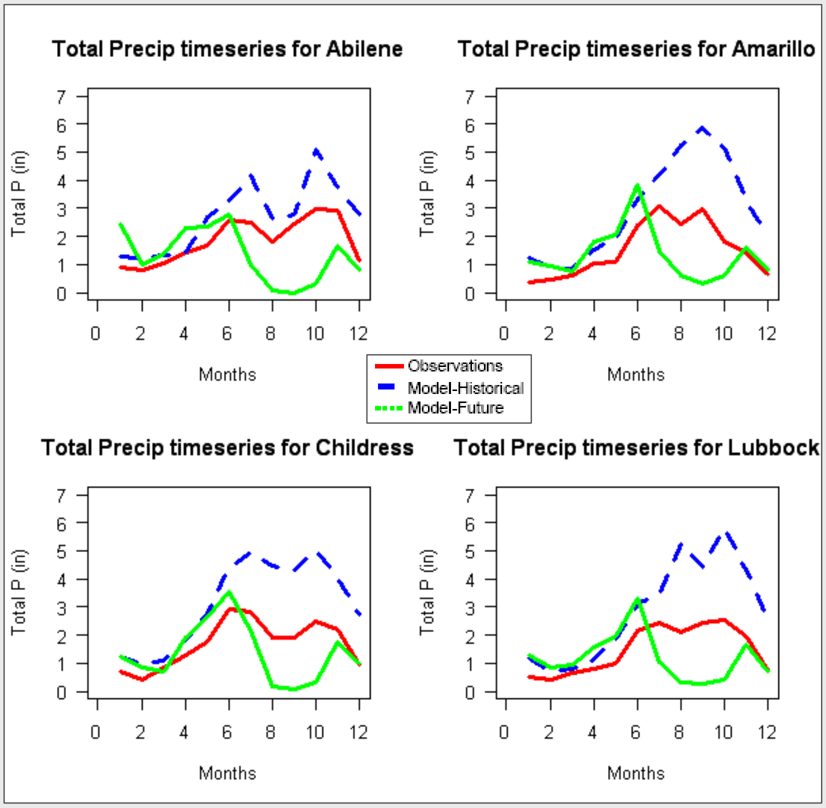
Climate Model	Physical Uncertainty	Socio-economic Uncertainty	High Projections	Low Projections
GFDL	18	6	11	13
PCM	16	7	5	18
CCSM	14	9	13	10
HaDCM3	15	7	8	14
MIROC	13	6	10	9
CSIRO	5	6	8	3
ECHAM5	5	1	5	1

GFDL, PCM, CCSM, and HaDCM3 selected from Method II.

Results and conclusions



Future run



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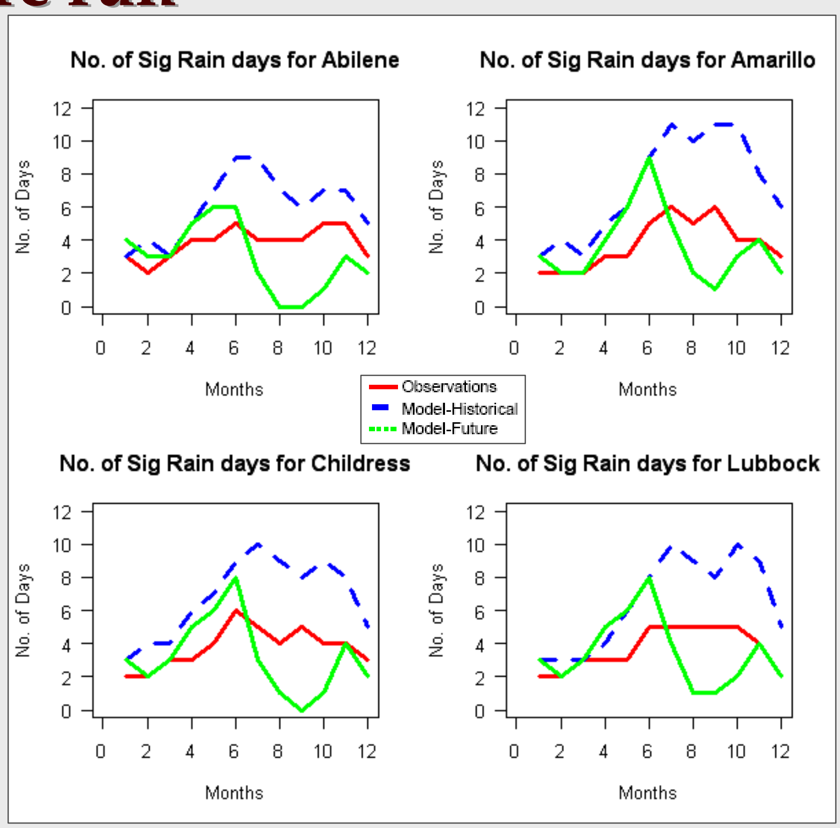

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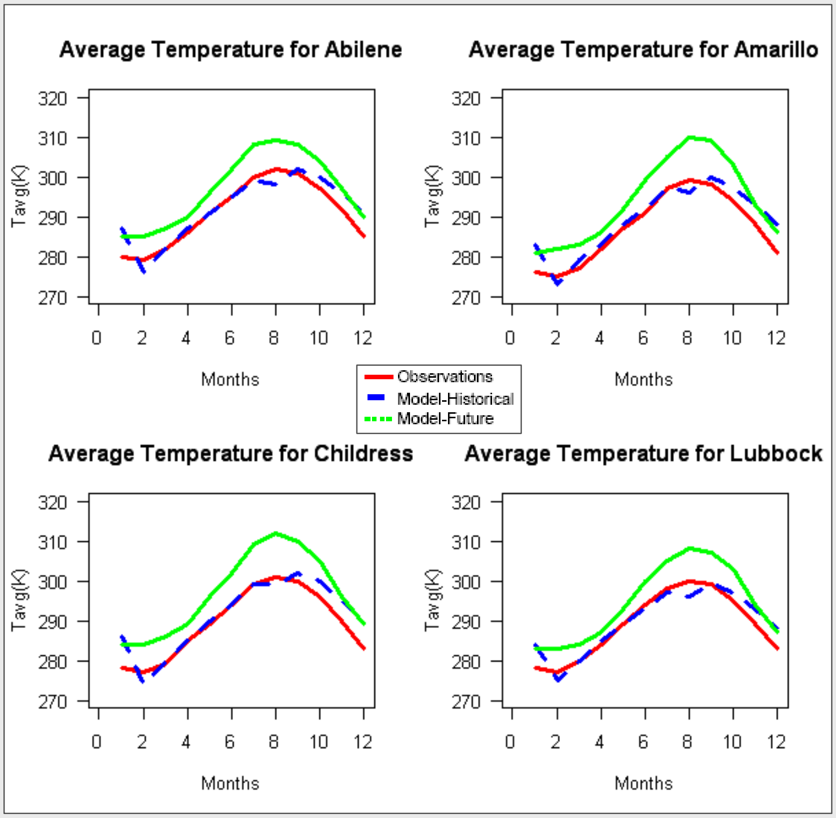

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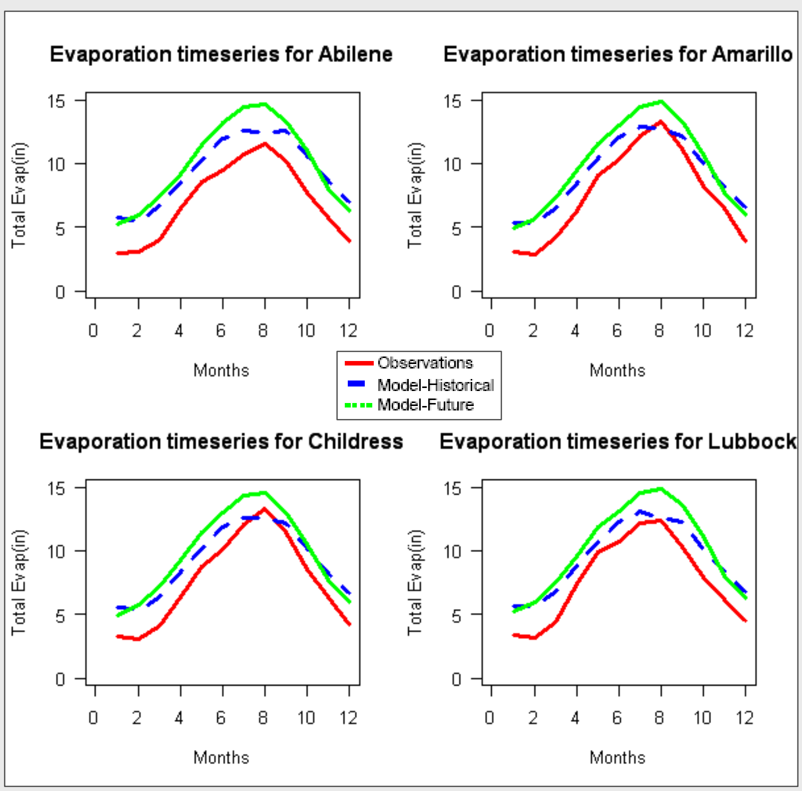

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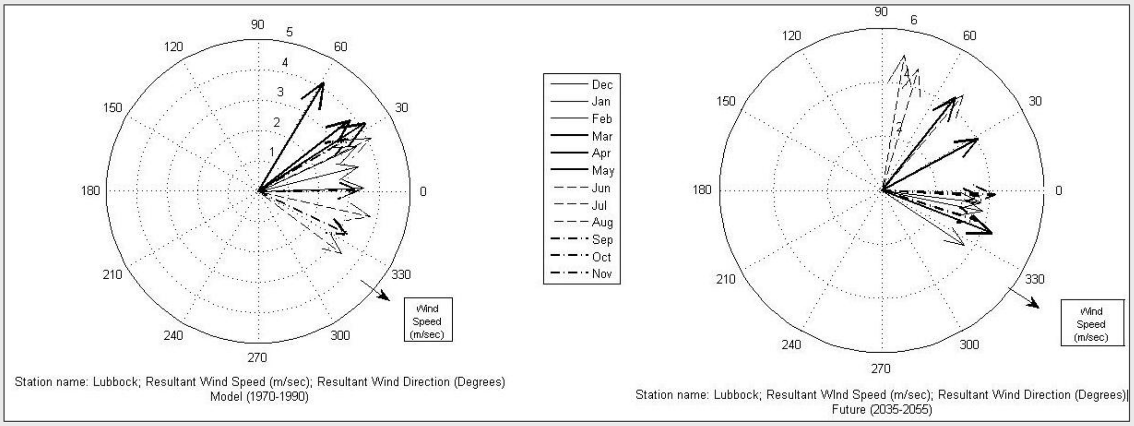

Conclusions of the study

Phase I

- MM5 can be used as a RCM for west Texas.
- Model -precipitation, temperature, and evaporation compared well with observations.

GCM comparison analysis

- CCSM is an appropriate GCM to drive RCMs for west Texas.
- Methodology for other GCM comparison analyses.

Phase II

- Temperature likely to increase during summer months,
- Precipitation is likely to decrease (intensity and frequency).
- Evaporation may increase, likely to decrease, and wind speed likely to increase.

Relevance of the study

Base run: TCEQ WAM Run #3.

Current Condition Run: Base run + year 2000 reservoir capacity.

Planned Condition Run: Base run + water management strategies from regional plans + estimated year 2060 reservoir capacity.

Predicted Condition Run: Planned condition run + assumed inflow and evaporation changes due to climate change (2060).

Determination of Surface water supply, reproduced with permission of Dr. Yujuin Yang, TWDB.

Scope of Work (TWDB)

RFQ in Texas Register (TexReg Document No. 33. Date of Publication, November 28, 2008).

Submitted Proposal on Jan 13, 2009.

– *"Assessment of General Circulation Models for Water-Resources Planning Applications"*

Board Shortlisted the Proposal in March, 2009.

Project work to commence in July, 2009.

Thank you for your Time.

For additional Questions,
Please Contact

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Evaporation: Potential evaporation was not a direct output from MM5 model. It was represented by means of the variable latent heat of flux. The latent heat of flux is sum of three types of evaporation contributions: 1) direct evaporation from bare soil ($Edir$), 2) evaporation of precipitation intercepted by the vegetation canopy (Ec), and 3) transpiration from the vegetation canopy and roots (Et) [58].

Evaporation was calculated using

$$\text{Evaporation (mm/d)} = \frac{\text{Latent heat of flux}}{\text{Latent heat of vaporization} \times \text{density of water}}. \quad (3.10.4)$$

Model latent heat of flux in watt/m2 was converted to latent heat of flux in $\text{MJ/m}^2\text{d}$

Density of water $= 1000\ \text{kg/m}^3$

Latent heat of vaporization $= 2.45$ MJ/kg